

NAVAL POSTGRADUATE SCHOOL

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THESIS

DEVELOPMENT OF A NAVY RECRUITING VEHICLE BUDGET MODEL

by

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December, 1997

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DEVELOPMENT OF A NAVY RECRUITING VEHICLE BUDGET MODEL

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis attempts to develop a predicting model for Commander, Navy Recruiting Command (CNRC) and Recruiting District Commanding Officers to use in distributing vehicles to each Navy Recruiting District. The thesis attempts to identify the relevant data on vehicle activity and vehicle costs across four Navy Recruiting Areas and 31 Navy Recruiting Districts that will be useful in developing a model to predict the demand for vehicles. The data file consists of pooled, cross-sectional time-series data covering three fiscal years, 1995, 1996, and 1997, and 31 Recruiting Districts. This data file is used to estimate regression models of vehicle demand using ordinary least squares techniques. The candidate independent variables whose values are statistically significant are used as the explanatory (predictor) variables to explain the variation in the number of vehicles across Districts. The thesis concludes that there is a strong relationship between the number of enlisted production recruiters and total vehicle mileage in explaining the number of recruiting vehicles. Using these relationships a simple model is developed that can be used to predict future vehicle demand by District and assist decision makers in making vehicle distribution decisions.

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I. INTRODUCTION

The military recruiting commands have changed the way they do business in response to the downsizing of the Defense Department. In the early 1990's, initiatives were set by the services to significantly reduce costs and better manage their recruiting resources by employing such methods as staff reductions. In a 1993-1994 study conducted by the U.S. General Accounting Office (GAO) on the Defense Department's recruiting management policies and operations, several issues were evaluated including the services' future plans for recruiting staffs and organizations. One of the GAO's recommendation in the 1994 report was to continue efforts to streamline the current recruiting organizational structure [Ref. 1].

A number of initiatives to reduce the size of recruiting staffs and several proposals to streamline recruiting organizations have been implemented. The most recent law enacted in October 1992, the National Defense Authorization Act for Fiscal Year 1993, required the services to reduce the number of personnel carrying out recruiting activities in the active and reserve forces by 10 percent. This cut was to be achieved by the end of fiscal year 1994 from 1992 levels.

Past DoD, service, and congressional proposals included several changes: the elimination of certain recruiting command management layers; the consolidation of common logistical support functions into one support command; the establishment of a joint DoD recruiting organization; the consolidation of each service's reserve, active, and

Guard recruiting; and the consolidation of medical recruiting activities. [Ref. 1] Many of these proposals have been discussed, but few have been implemented.

Since 1989, the Navy has reduced its recruiting management organization by eliminating two of its six Navy Recruiting Areas (NRA's) and by eliminating 10 of its four Navy Recruiting Districts (NRD's). Although the fiscal year 1995 National Defense Authorization Act repealed the required 10 percent reduction from the National Defense Authorization Act for Fiscal Year 1993, the Navy had already begun reducing its manning by approximately 17 percent. Commander, Navy Recruiting Command (CNRC) will begin phasing out entirely one of its management layers, the four recruiting Areas, in 1998 as a consequence of the recommendation in the 1994 GAO report to "...streamline the recruiting bureaucracy, eliminating layers where possible...", [Ref. 1].

A. RECRUITING ORGANIZATION IN THE NAVY

Although the military services have reduced the size of different recruiting management layers, the basic recruiting structure remains the same. As of the end of 1997, the Navy's recruiting organization has five management layers. The first three echelons of the organization provide the management of recruiting resources and support. Table 1 describes the organizational structure of the Navy's recruiting hierarchy.

The headquarters (CNRC) is commanded by an O-7, equivalent to a one-star admiral, and is staffed with expert support personnel in the areas of marketing, finance and recruiting policies. The Commander is responsible for the recruitment of men and women for enlisted, officer candidate, and officer status in the Regular component of the Navy.

Echelon	Navy
I	CNRC - National headquarters Commander, Navy Recruiting Command (CNRC), located in Arlington, Virginia
II	Areas - Four Recruiting Areas (NRA) located across the nation
III	Districts - 31 Recruiting Districts (NRD)
IV	Zones - 190 zones
V	Stations - 1,414 full and part-time recruiting stations (NRS)

Table 1.1. Navy Recruiting Organizational Hierarchy
Source: SRA Study [Ref. 2]

The headquarters level is responsible for coordinating and supervising Navy Recruiting Command support personnel, providing public affairs guidance, responding to media inquiries regarding recruiting matters, developing and disseminating information concerning Navy and command policies, and allocating resources necessary to achieve command objectives.

The Area offices are headed by O-6's, or captains, who coordinate and oversee public affairs activities. They provide guidance, training, and assistance to district commanding officers in the development and execution of public affairs plans. They identify issues and situations that may have a potential impact on Navy recruiting by providing responses to media inquiries concerning recruiting matters. Additionally, they allocate resources to their districts as necessary. Navy recruiting district commanding officers are O-5's, or commanders, who carry out the same type of responsibilities as the area commanders except their responsibilities are confined to their assigned district.

Navy recruiting zones are headed by an E-8, a Senior Chief Petty Officer, or an

E-9, a Master Chief Petty Officer. Zone supervisors are usually Career Recruiter Force (CRF) personnel whose careers are dedicated solely to recruiting. Zones are composed of several recruiting offices usually employed with 25-30 recruiters. Zone supervisors spend the majority of their time on the road visiting the Navy Recruiting Stations (NRS's) and the recruiters under their administrative care.

Below the zone supervisory level are the stations. This level consists of recruiters functioning in the field. The sole function of a NRS is to provide a place from which recruiters can canvass for new recruits, administer aptitude screening tests, assess an applicant's potential, process the necessary documentation for new recruits, complete administrative tasks, and provide publicity material to the area schools and neighborhoods. [Ref. 2]

B. PURPOSE OF THESIS

With the planned elimination of the four Area staffs in 1998, CNRC will have to allocate resource budgets directly to the Districts vice through the Areas. In preparation for directly allocating budgets to 31 NRD's, the comptroller of CNRC requested analytical assistance in developing a model to assist in fairly distributing funds of resources based on objective, quantifiable measures. This model would predict the costs of various recruiting resources. After examining typical NRD budget expenditures by category, vehicle costs became the focus of the study. The goal of this thesis is to develop a model for CNRC to use in allocating vehicles to the NRD's. The model will also be used by CNRC to fairly distribute vehicle funding based on objective, quantifiable measures.

C. SCOPE OF THESIS

The thesis will evaluate current and past vehicle budgets across 31 Navy Recruiting Districts based on two main factors: (1) the numbers of vehicles allocated in the past, and (2) the amount of vehicle usage. The thesis will identify and collect the relevant data on vehicle costs that will be useful in analyzing the distribution of vehicles to Recruiting Districts. It will aggregate relevant recruiting data and vehicle cost data by Area and District. This aggregate will be used to estimate cost models using ordinary least squares regression analysis.

Chapter II will discuss the background of the vehicle management and budget process currently used by the Area and District commands. It will also discuss collection of data on vehicle expenditures for four Recruiting Areas. Chapter III will describe the methodology of this thesis, including a discussion of the determinants to be included in the cost estimating model. This chapter also explains the regression procedure used to analyze the cost data. Chapter IV will discuss and present the results of the cost estimating model. This chapter will also evaluate the accuracy of the model for forecasting vehicle costs. Lastly, Chapter V will review the results and address the effort entailed in identifying and collecting the data. It will also make recommendations for future analysis.

II. BACKGROUND

The Navy's policy regarding mission accomplishment is to have sufficient resources and to optimally distribute these resources to achieve recruiting objectives. This thesis is an attempt to develop a model that Navy Recruiting Districts (NRD's) and Headquarters, Recruiting Command (CNRC) can use to distribute a set number of vehicles for their districts.

The main objectives of this chapter are to identify relevant data regarding government-leased vehicles at different station locations and to evaluate the data for estimating an ordinary least squares regression model. To accomplish these objectives the chapter reviews the Navy's responsibilities, policies, procedures and rationale in determining recruiting vehicle distribution decisions. Questions to ask are whether distribution decisions are based on satisfying mission requirements (contracts) with the most efficient use of resources (vehicles), and whether a valid model can be formulated to aid in meeting these goals? This question is being addressed because of current Department of Defense (DoD) budget constraints and the planned restructuring of the Navy recruiting command.

A. VEHICLE MANAGEMENT

General Services Administration (GSA) Interagency Fleet Management System provides transportation support to executive agencies of the federal government. Vehicle users pay a flat monthly rental charge plus a charge per mile for use of vehicles. There is

no additional charge for fuel, planned maintenance and replacement vehicles; however, Commands must pay for accidents, vandalism costs and repairs.

Commander, Navy Recruiting Command (CNRC) authorizes vehicle acquisition and distribution to each Area command in accordance with a vehicle allowance model. Under the current model, the number of vehicles are allocated in direct proportion to the number of billets filled for each district. For example, an Enlisted Programs Officer (EPO) and Officer Programs Officer (OPO) for a district will each be allocated one vehicle. Likewise, for every four enlisted recruiters, three vehicles will be allocated and for every two officer recruiters, one vehicle will be allocated. Table 2 shows the current vehicle allowance model used, and although it appears sound, the question arises as to whether the model distributes resources in an optimal manner?

CNRC approves an overall vehicle allowance, based upon basic manpower allowance for billets authorized (BA), for each Recruiting Area which in turn distributes vehicles among their Recruiting Districts. Area Commands submit annual vehicle authorization calculations by August 1st to CNRC for approval. These calculations must show allowances for the Area Headquarters and each subordinate District based on BA figures for the upcoming fiscal year.

Districts can forward requests for vehicle allowance changes to their appropriate Area command. The Area then reviews their overall allowance to determine if a change to the Area's allowance is required. If a change to the Area's overall vehicle allowance is necessary, the Area will submit a request to CNRC for an allowance change. The request

must provide specific justification for the allowance change and indicate that a review of all available assets was conducted. Under the new planned recruiting organization, the Recruiting Districts will forward their vehicle requests directly to CNRC for approval.

RECRUITING ACTIVITY	VEHICLES/ACTIVITY
AREA HEADQUARTERS	
COMMAND	1
POOL	5
TOTAL	1
DISTRICT HEADQUARTERS	
COMMAND	1
OPO	1
EPO	1
CHIEF RECRUITER	1
POOL	8
DISTRICT TRAINERS	1
TOTAL	8
ZONE SUPERVISORS	1
OFFICER RECRUITERS	0.50
ENLISTED RECRUITERS	0.75

Table 2.1. Vehicle Allowance Model

Source: Logistics Support Manual [Ref. 3]

1. Recruiting Resources Management

The Navy's recruiting mission is funded from the Operation and Maintenance, Navy (O&M,N) appropriations account and falls under Budget Activity (BA) Three, Training and Recruiting. The Navy's financial manager and comptroller (ASN (FM&C)) allocates the appropriations to the office of the Chief of Naval Operations (CNO) through which budget authority for all O&M,N appropriations flow. The Chief of Naval Personnel (CNP), who is CNRC's major claimant, issues an Operating Budget to CNRC for recruiting activities and advertising. The Navy's recruiting budget pays for all recruiting activities which are divided into two categories: recruiting support and national and local level advertising. Vehicle management and transportation costs, which are the focus of this study, fall under recruiting support. Vehicle budget costs for each Area encompass leasing costs, mileage costs, and accident costs for each type of vehicle.

2. Recruiting Optimization Models

The Navy uses optimization models to assign territory to Recruiting Stations and then to assign recruiters to stations. The models incorporate an analysis of optimal distances from the target market and the size of the market which affects the number of recruiters assigned as well as the size of the station. Production factors drive many of the models, with each variable having a weight assigned according to its contribution to production. For example, the production of a particular station can be a function of the driving distance of the Recruiting Stations to the 'centroid' (center) of a zip code of a

target market or recruiting zone [Ref. 2]. Distances are measured based on the latitude and longitude of the zip code centroids.

CNRC marketing division developed an optimization model for allocating recruiting resources to determine the most cost effective mix of resources including advertising dollars. The model incorporated the following variables: (1) the population of 17-21 year old males in a zip code; (2) the population density in a zip code; (3) past production success by all services in recruitable market; and (4) the distance in miles from existing locations to the centroid [Ref. 9]. This Navy optimization model is used to maximize production goals and do not take recruiting station costs into account. However, this analysis of the recruiting optimization model will be helpful in determining some of the candidate explanatory variables in the vehicle forecasting model.

B. DATA COLLECTION

Although there are some limitations on the variables considered for the forecasting model due to a limited amount of data, there still exists a substantial set of possible variables that could be used to measure both the dependent and independent variables of the model. The data collection was conducted over a period of several months by the CNRC Operations Analysis Department, Code 221, in their initial attempt to develop a new distribution model for recruiting vehicles.

The data collected covered a period of three fiscal years: 1995, 1996 and 1997. It was collected from all four Navy Recruiting Area commands and the 31 Navy Recruiting Districts. The data was then classified into the following eight categories: (1) total

number of Career Recruiting Force (CRF) personnel and enlisted personnel with the 9585 recruiting designator; (2) total number of vehicles onboard; (3) total mileage for the vehicles; (4) total cost of the vehicles; (5) total number of enlistment contracts; (6) square mileage of each District's territory; (7) total cost of vehicle accidents; and (8) leasing costs and mileage costs per vehicle type in each Area.

Each of these variables were chosen because of their potential to contribute to the proposed predicting model. The variables were separated into two categories: (1) quantitative data, such as the number of recruiters, contracts, vehicle mileage; and (2) vehicle cost data, such as lease costs, mileage costs, and accident costs. The rationale behind this separation was to ensure the consistency of variables used to determine the dependent variable. For example, in developing a predicting model for the *allocation of vehicles*, none of the vehicle cost data would be used as an independent variable because cost factors would be inappropriate in determining the number of vehicles allocated. Rather, these variables would be more appropriate in determining the *allocation of a vehicle budget*. Since the current system allocates the number of vehicles based on manpower, the use of vehicle cost data to determine the number of vehicles allocated did not appear consistent. If the current allocation system was based on monetary factors, it would be logical to use the vehicle data costs to determine this relationship.

In summary, the chapter reviewed the current vehicle allocation procedures and the model used by the Navy recruiting commands. It provided some insight into the resource management of recruiting assets and the rationale behind recruiting station

location and assignments. Finally, it described the process of data collection and selection of various determinants to be used in a regression-based forecasting model. The next section will review the methodology used in the model testing procedure and the techniques used to evaluate the results of the test.

III. METHODOLOGY

This chapter presents a detailed explanation of the methodology used in this thesis. The statistical technique chosen was a multiple regression model using the Minitab software program for data analysis stored on the classroom support computer lab located at the Naval Postgraduate School (NPS). The statistical procedures in the Minitab package are designed for several types of statistical analysis. The rationale behind the use of ordinary least squares regression analysis is presented. Furthermore, the basic assumptions of this technique will be included in this explanation as well as the statistical procedures used to validate the model.

A. BASIC CONCEPTS OF REGRESSION

Regression was chosen as the quantitative method for this study because of its ability to predict the value of one variable based on the values of other linearly related, “explanatory” variables. Regression analysis has been defined as “a technique of quantifying relationships between two or more variables ... concerned with the problem of describing or estimating the value of one variable on the basis of one or more other variables.” [Ref. 3]

Regression analysis can be used to describe, to control, and to predict. These functions can be of major assistance to managers. The purpose of this study is to use the results of the regression model to predict the number of vehicles needed at each of 31 recruiting districts.

B. BASIC FORMAT OF THE REGRESSION MODEL

The basic format of a regression model is:

$$Y_e = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon,$$

where Y_e = the expected average value for the dependent variable, the number of vehicles to be predicted; ε = the error term; α = the intercept; β 's = the slopes of the lines. The independent variables in the model in this thesis are X_1 = number of recruiters and X_2 = square mileage per district. The equation is estimated using ordinary least squares, the objective of which is to find a line that minimizes the sum of the squared error terms of the regression model.

C. BASIC FUNCTIONS OF REGRESSION

Ordinary least squares is the most common method for locating the regression line so that the line lies at the center of the range of observations. It determines the values of α and β so that the sum of the squared deviations between the observations and the fitted line is less than that from any other straight line that could be fitted through the observations. [Ref. 3]

Since the regression model represents the average relationship between the dependent variable and the independent variable, random deviations are inevitable. Thus, the least squares method is a useful tool to find the 'best-fitting' line which passes close to all the data points so that the distance of each data point from the line is minimized.

D. STATISTICAL ASPECTS OF REGRESSION

A primary method to measure the goodness-of-fit of the regression line is the coefficient of determination, denoted by R^2 . The coefficient of determination is useful for interpreting how much of the sample variation from the mean of the dependent variable can be explained by the change in the independent variables. For example, if $R^2 = 0.70$ in a simple linear regression model, then a change in the independent variable, X , will explain 70 percent of the variation in the dependent variable, Y .

The value of R^2 can be adjusted for the loss of degrees of freedom in a multiple regression model. Without this adjustment, the addition of more explanatory variables, regardless of their explanatory power, will always result in higher values of R^2 . The corrected coefficient, or adjusted R^2 , can decline if an additional explanatory variable is insignificant relative to the degrees of freedom in the equation. Adjusted R^2 is useful when comparing the explanatory power of different sets of explanatory variables. [Ref. 3]

E. STATISTICAL TESTS

The following statistical tests were used to validate the model: t-test; F-test; and p-value. Each of these tests will be fully explained in the subsequent paragraphs.

The t-test determines if the value of a slope, β , is significantly different from zero. Therefore, a t-ratio of 14 indicates that the value of the slope of the regression equation is 14 standard errors from zero. In general, a high t-value (>2.0) implies that the β coefficient is unlikely to be a random variation from zero. It also indicates that the independent variable is important in explaining the variation of the dependent variable.

Another tool which allows us to test the statistical significance of a regression model is the F-test. Like the t-test, the F-ratio tests whether or not the β coefficient is a random deviation from zero. An F-test is usually a ratio of two numbers, where each number estimates a variance. An F-test is used in analysis of variance, where it tests the hypothesis of equality of means for two or more groups. For instance, in an Analysis of Variance (ANOVA) test, the F-statistic is usually a ratio of the Mean Square Regression hypothesis of equality of means for two or more groups. For multivariate models, the F-statistic tests joint hypothesis that $\beta_1 + \beta_2 + \dots + \beta_n = 0$.

P-values are often used in hypothesis tests, where you either reject or fail to reject a null hypothesis. The p-value represents the probability of making a Type 1 error, which is rejecting the null hypothesis when it is true. The smaller the p-value, the smaller is the probability of making a mistake by rejecting the null hypothesis. A cut-off value often used is 0.05, which means reject the null hypothesis when the p-value is less than 0.05. The p-value also helps to determine statistical significance of the F-statistic. [Ref. 4]

In summary, this chapter gave a brief description of the methodology used in this thesis. A description of the statistical procedures and tests used in the ordinary least squares regression analysis was presented. The next section will present the results of the data collection using regression analysis and will analyze the significance of the predicting model.

IV. REGRESSION ANALYSIS

This chapter presents a synopsis of various vehicle estimating models and the steps used to derive them. An examination of these results will focus on the models and the particular statistical tests for evaluating the results. Finally, a summary of the ‘best’ predicting model will be presented and analyzed for its significance to CNRC and its usefulness in distributing vehicles.

A. VARIABLE SELECTION

The data collection was conducted over a period of several months by the CNRC Operations Analysis Department, Code 221, in their initial attempt to develop a new distribution model for recruiting vehicles. The data file consists of pooled, cross-sectional, time-series data covering three fiscal years: 1995, 1996 and 1997, from all four Navy Recruiting Area commands and 31 Navy Recruiting Districts. Table 4.1 displays the variables and the data for each variable by District. At the time this study was conducted, information on contracts and mileage for FY97 was unavailable, thus the thesis focuses on fiscal years 1995 and 1996.

As previously mentioned in Chapter II, the variables were separated into two categories: (1) activity data, such as number of recruiters, enlistment contracts, and vehicle mileage; and (2) vehicle cost data, such as lease costs, mileage costs, and accident costs. This study focuses on developing a predicting model for use in distributing vehicles across Districts. As such, none of the vehicle cost variables mentioned in Chapter II

NRA	NRD	NRD NAME	SIZE	FY 95 RECS	FY 95 VEHS	FY 95 CON	FY95 MILEAGE	FY 96 RECS	FY96 VEHS	FY 96 CON	FY96 MILEAGE	FY97 RECS	FY97 VEH
1	102	NEW ENGLAND	48497	146	137	1819	2,235,840	135	134	1518	1,784,880	132	130
1	103	BUFFALO	48378	125	120	1539	1,821,600	126	126	1701	1,980,720	128	119
1	104	NEW YORK	5258	128	123	2197	1,936,512	129	130	2105	2,010,840	133	124
1	119	PHILADELPHIA	18187	136	125	1822	1,746,000	155	137	1844	1,819,908	167	139
1	120	PITTSBURGH	55032	97	91	1279	1,555,008	134	123	1532	2,187,432	129	122
3	310	MONTGOMERY	83526	127	109	1780	2,160,816	130	114	1503	2,362,536	134	114
3	312	JACKSONVILLE	50758	118	97	1646	1,663,356	125	111	1495	1,883,448	136	108
3	313	ATLANTA	59530	159	129	2097	2,382,372	158	136	1836	2,467,584	171	138
3	314	NASHVILLE	78486	113	110	1340	2,032,800	122	117	1390	2,155,140	128	116
3	315	RALEIGH	54039	138	113	1645	2,120,784	135	117	1530	2,198,664	126	115
3	316	RICHMOND	51327	126	110	1694	1,826,880	137	123	1805	2,002,932	139	120
3	318	OHIO	32934	138	131	1461	1,826,664	137	130	1359	2,113,800	137	130
3	334	NEW ORLEANS	76707	115	99	1412	1,569,348	120	112	1433	1,928,640	117	111
3	348	MIAMI	18155	131	105	1620	1,602,720	129	113	1658	1,574,316	129	111
5	521	CHICAGO	26438	115	118	1482	2,003,640	136	123	1561	2,113,632	130	118
5	527	KANSAS CITY	145183	124	123	1508	1,738,728	124	128	1526	2,147,328	129	121
5	528	MINNEAPOLIS	116090	101	122	1237	1,632,360	111	109	1131	1,807,656	121	91
5	529	OMAHA	286714	83	100	1009	1,437,600	110	108	1178	2,130,624	119	100
5	531	DALLAS	77534	118	101	1703	1,645,896	129	110	1606	1,877,040	137	105
5	532	HOUSTON	53263	127	112	1993	1,838,592	128	115	1612	1,989,960	126	127
5	542	INDIANAPOLIS	37098	104	105	1184	1,513,260	107	106	1248	1,949,976	119	117
5	547	ST LOUIS	94376	130	128	1744	2,489,856	128	125	1694	2,277,000	134	121
8	822	MICHIGAN	42829	141	134	1287	1,829,904	140	134	1455	2,190,096	128	125
8	825	DENVER	214129	87	86	1205	1,375,656	99	85	1201	1,513,680	105	87
8	830	ALBUQUERQUE	187456	94	85	1309	1,296,420	109	97	1396	1,337,436	114	110
8	836	LOS ANGELES	29605	150	138	2530	2,348,208	171	138	2639	2,316,744	182	140
8	837	PORTLAND	322514	91	86	1402	1,348,824	106	98	1362	1,527,624	122	95
8	838	SAN FRANCISCO	89683	158	133	2366	2,259,936	182	140	2414	2,629,200	186	143
8	839	SEATTLE	222780	99	92	1548	1,277,328	119	106	1571	1,624,344	129	98

Table 4.1. Vehicle Data by Recruiting Area and District

were used as predictor variables in the regression models because these cost factors would be inappropriate in determining the distribution of vehicles.

In developing a model for the distribution of vehicles to each district, the independent variables were screened for potential explanatory ability. The dependent variable and the candidate explanatory variables are defined as follows:

Dependent Variable:

- (1) Vehicles (VEHS) = Number of vehicles onboard for the fiscal year.

Explanatory Variables:

- (1) Recruiters (REC) = Number of enlisted production recruiters by District;
- (2) Contracts (CON) = Number of new enlistment contracts;
- (3) Mileage = Total number of mileage for vehicles onboard; and

(4) Size = District size (in square miles).

One of the requirements for using the least squares method is ensuring that the relationship between the dependent variable and the explanatory variables is linear before any valid statistical inference can be made. One method to ensure linearity exists is to conduct data transformations of all the variables involved. In this study, all the independent, explanatory, variables were plotted against the dependent variable, number of vehicles. Figures 4.1-4.4 display the plots of each explanatory variable from FY95 and FY96 pooled data. The plots display a linear relationship and, thus the data requires no transformation.

Next, these variables were tested for multicollinearity, the condition that explanatory variables are partially related to each other. Table 4.2 displays the correlation coefficients for the explanatory variables. As a general rule, a simple coefficient of more than 0.7 between any two explanatory variables can cause multicollinearity[Ref. 3]. Multicollinearity is a potential problem because it can increase the standard errors of the collinear variables and thus reduces their statistical significance. However, when the model is to be used mostly for prediction purposes, this problem is not as serious as for other uses because the coefficients are still reliable.

Table 4.2 shows that multicollinearity exists between the Recruiter and Contract variables and between the Recruiter and Mileage variables, which have correlation coefficients above 0.7. This signifies that the explanatory variables, Contract and Recruiter and Recruiter and Mileage move simultaneously in the same direction and at

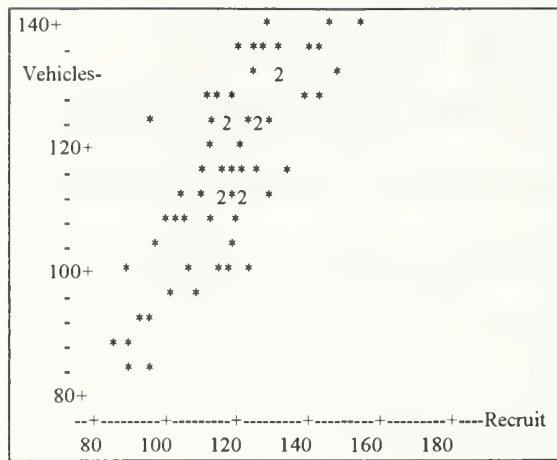


Figure 4.1. Vehicles vs Recruiters

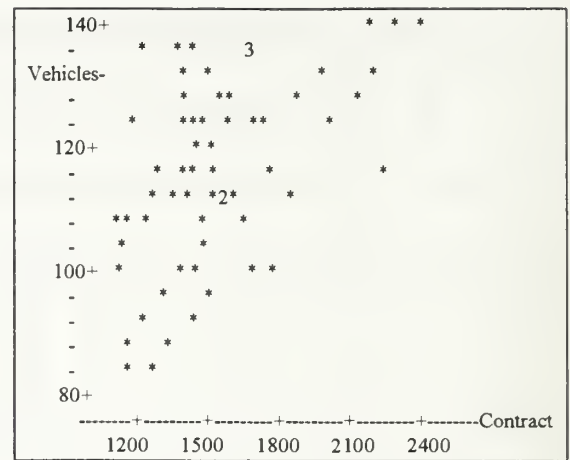


Figure 4.2. Vehicles vs Contracts

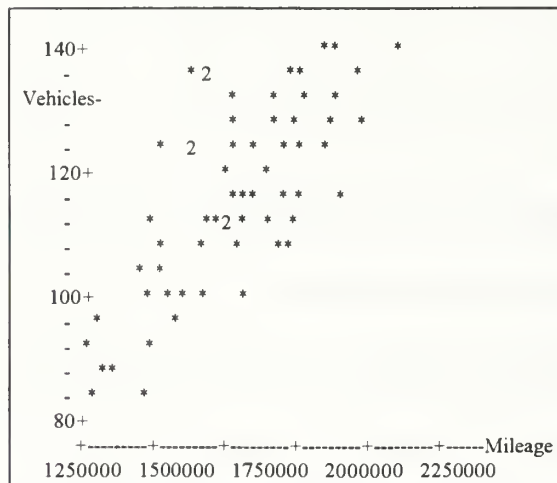


Figure 4.3. Vehicles vs Mileage

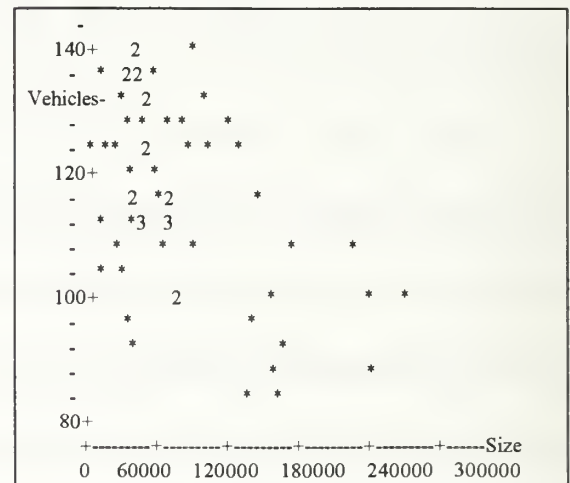


Figure 4.4. Vehicles vs Size

	Contract	Mileage	Recruiter	Size
Mileage	0.537			
Recruiter	0.768	0.765		
Size	-0.360	-0.442	-0.568	
Vehicles	0.538	0.757	0.833	-0.588

Table 4.2. Correlation Coefficients for Vehicle Data

approximately the same rate. Thus, estimates of the individual coefficients for these variables are less reliable because the other explanatory variables can not be held constant.

All of these independent variables were inputted into the Minitab least squares regression model. The Minitab regression function tested each variable's t-ratio, F-statistic, and p-value. Only those variables with statistically significant F-values, p-values (values < 0.05) and individual t-ratios (values ≥ 2) were kept in the estimating model.

Multiple regression analysis was used to test the significance of all four candidate variables as the independent variables in determining the dependent variable, the number of vehicles. The variables whose values were statistically significant were used as the explanatory (predictor) variables.

B. RESULTS OF ESTIMATING A LINEAR MODEL FOR FY95

The result is represented by the following equation:

$$Y \text{ (predicted vehicle allowance)} = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

where X_1 equals Recruiters and X_2 equals Mileage. The result of estimating this model is:

$$\text{FY95 Vehicles} = 31.3 + 0.406 (\text{Recruiters}) + 0.000017 (\text{Mileage})$$

Figure 4.5 shows the full Minitab results for the regression analysis estimated using FY95 data. The number of recruiters and the total vehicle mileage variables were determined to be statistically significant as evidenced by the t-ratios greater than 2.0, a high F-statistic (32.5), and an adjusted R^2 of 0.678. Contracts and Size variables were dropped because of their low t-ratios and p-values. Figure 4.6 displays the Minitab results for a model that

The regression equation is: **FY95 VEHICLES = 31.3 + 0.406 (Recruiters) +0.000017 (Mileage)**

Predictor	Coef	StDev	T	P
Constant	31.34	10.18	3.08	0.005
Recruiters	0.4064	0.1386	2.93	0.007
Mileage	0.00001719	0.00000858	2.00	0.055

S = 9.039 R-Sq = 69.9% R-Sq(adj) = 67.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	5319.8	2659.9	32.56	0.000
Error	28	2287.6	81.7		
Total	30	7607.4			

Source	DF	Seq SS
Recruiters	1	4992.2
Mileage	1	327.6

Figure 4.5. FY95 Minitab Result Using Recruiters and Mileage Variables.

The regression equation is:

FY95 VEHICLES = 33.1 + 0.540 (Recruiters) +0.000019 (Mileage) - 0.0120(Contracts) -0.000009 (Size)

Predictor	Coef	StDev	T	P
Constant	33.09	14.85	2.23	0.035
Recruiters	0.5395	0.1799	3.00	0.006
Mileage	0.00001864	0.00000834	2.24	0.034
Contracts	-0.011993	0.006549	-1.83	0.079
Size	-0.00000891	0.00002690	-0.33	0.743

S = 8.737 R-Sq = 73.9% R-Sq(adj) = 69.9%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	5622.5	1405.6	18.41	0.000
Error	26	1984.9	76.3		
Total	30	7607.4			

Source	DF	Seq SS
Recruiters	1	4992.2
Mileage	1	327.6
Contracts	1	294.3
Size	1	8.4

Figure 4.6. FY95 Minitab Results Adding Contract and Size as Explanatory Variables.

includes Contracts and Size as the independent variables. The F-statistic for the overall model falls by half, and t-ratios for Contracts and Size are below 2.0.

The F-value for the FY95 estimating model (in Table 4.5) is 32.56. This F-value rejects the null hypothesis that the β 's in the model are jointly equal to zero. The t-tests of the individual Beta coefficients, 3.08 for the constant coefficient value, 2.93 for Recruiters, and 2.00 for Mileage, demonstrate that each variable contributes to predicting Y, the dependent variable. Likewise, the p-values, 0.005 for the constant coefficient, 0.007 for Recruiters and 0.055 for Mileage indicate that we can reject the null hypothesis that the Beta coefficients are equal to zero. Even though the t-ratio and p-value for total vehicle mileage are not highly significant compared to the rule of thumb values of significance for t-ratios (values ≥ 2) and p-values (values < 0.05), the variable remains a candidate explanatory determinant.

The last statistic to be discussed is the adjusted coefficient of determination, adjusted R^2 . The adjusted R^2 for this model is 67.8 percent. This means that X_1 and X_2 account for (or explains) an estimated 68 percent of the variation of Y (the predicted allowance of vehicles), the dependent variable.

C. RESULTS OF ESTIMATING A LINEAR MODEL FOR FY96

The result is represented by the following equation:

$$Y \text{ (predicted vehicle allowance)} = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

where X_1 equals Recruiters and X_2 equals Size. The result estimating this model is:

$$\text{FY96 Vehicles} = 56.9 + 0.506 (\text{Recruiters}) - 0.000045 (\text{Size}).$$

Figure 4.7 shows the Minitab results for the regression analysis estimated using FY96 data. The number of recruiters and the District size variables were determined to be statistically significant as evidenced by the t-ratios greater than 2.0, a high F-statistic (45.2), and an adjusted R^2 of 0.747. Contracts and Mileage variables were dropped because of their low t-ratios and p-values. Figure 4.8 displays the Minitab results for a model that adds Contracts and Mileage as the independent variables. The F-statistic falls by half, and t-ratios for Contracts and Mileage are below 2.0.

The F-value for the FY95 estimating model is 45.24. This F-value rejects the null hypothesis that the β 's in the model are jointly equal to zero. The t-tests of the individual Beta coefficients, 5.14 for the constant coefficient value, 6.59 for Recruiters, and 2.50 for Size, demonstrate that each variable contributes to predicting Y, the dependent variable. Likewise, the p-values, 0.000 for the constant coefficient, 0.000 for Recruiters and 0.019 for Size indicate that each variable contributes to predicting the Y value.

The last statistic to be discussed is the adjusted coefficient of determination, adjusted R^2 . The adjusted R^2 for this model is 74.4 percent. This means that X_1 and X_2 account for (or explains) an estimated 74 percent of the variation of Y (the predicted allowance of vehicles), the dependent variable.

D. RESULTS OF ESTIMATING A LINEAR MODEL FOR FY97

The result is represented by the following equation:

$$Y \text{ (predicted vehicle allowance)} = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

The regression equation is: $FY96\ VEHICLES = 56.9 + 0.506(Recruiters) - 0.000045(Size)$

Predictor	Coef	StDev	T	P
Constant	56.85	11.05	5.14	0.000
Recruiters	0.50561	0.07669	6.59	0.000
Size	-0.00004456	0.00001784	-2.50	0.019

S = 6.706 R-Sq = 76.4% R-Sq(adj) = 74.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	4069.5	2034.7	45.24	0.000
Error	28	1259.2	45.0		
Total	30	5328.7			

Source	DF	Seq SS
Recruiters	1	3789.1
Size	1	280.4

Figure 4.7. FY96 Minitab Result Using Recruiters and Size Variables.

The regression equation is:

$FY96\ VEHICLES = 48.3 + 0.482(Recruiters) - 0.000041(Size) + 0.000009(Mileage) - 0.00369\ FY96(Contract)$

Predictor	Coef	StDev	T	P
Constant	48.33	11.96	4.04	0.000
Recruiters	0.4818	0.1526	3.16	0.004
Size	-0.00004085	0.00001776	-2.30	0.030
Mileage	0.00000866	0.00000574	1.51	0.144
Contract	-0.003694	0.006204	-0.60	0.557

S = 6.567 R-Sq = 79.0% R-Sq(adj) = 75.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	4207.6	1051.9	24.39	0.000
Error	26	1121.1	43.1		
Total	30	5328.7			

Source	DF	Seq SS
FY96 CRF	1	3789.1
MILES SQ	1	280.4
FY96MILE	1	122.8
FY96 CON	1	15.3

Figure 4.8. FY96 Minitab Results Adding Mileage and Contract as Explanatory Variables.

where X_1 equals Recruiters and X_2 equals Size. The result estimating this model is:

$$\text{FY97 Vehicles} = 64.4 + 0.444 (\text{Recruiters}) - 0.000077 (\text{Size}).$$

Figure 4.9 shows the Minitab results for the regression analysis estimated using FY97 data. The number of recruiters and the District size variables were determined to be statistically significant as evidenced by the t-ratios greater than 2.0, a high F-statistic (39.8), and an adjusted R^2 of 0.721. Unlike FY95 and FY96 data, the number of new contracts and the total vehicle mileage data were not available for FY97 and could not be evaluated as predictor variables, thus we place limited reliance on this model.

The F-value for the FY97 estimating model is 39.75. This F-value rejects the null hypothesis that the β 's in the model are jointly equal to zero. The t-tests of the individual Beta coefficients, 5.76 for the constant coefficient value, 5.78 for Recruiters, and 4.19 for Size, demonstrate that each variable contributes to predicting Y, the dependent variable. Likewise, the p-values, 0.000 for the constant coefficient, 0.000 for Recruiters and 0.000 for Size indicate that each variable contributes to predicting the Y value.

The regression equation is: FY97 VEHICLES = 64.4 + 0.444 (Recruiters) -0.000077 (Size)					
Predictor	Coef	StDev	T	P	
Constant	64.40	11.18	5.76	0.000	
Recruiters	0.44384	0.07681	5.78	0.000	
Size	-0.00007660	0.00001829	-4.19	0.000	
S = 7.450 R-Sq = 74.0% R-Sq(adj) = 72.1%					
Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	4412.7	2206.3	39.75	0.000
Error	28	1554.0	55.5		
Total	30	5966.7			
Source	DF	Seq SS			
Recruiters	1	3439.5			
Size	1	973.2			

Figure 4.9. FY97 Minitab Result Using Recruiters and Size Variables.

The last statistic to be discussed is the adjusted coefficient of determination, adjusted R^2 . The adjusted R^2 for this model is 72.1 percent. This means that X_1 and X_2 account for (or explains) an estimated 72 percent of the variation of Y (the predicted allowance of vehicles), the dependent variable.

E. A POOLED ESTIMATING MODEL

The result is represented by the following equation:

$$Y \text{ (predicted vehicle allowance)} = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

where X_1 equals Recruiters and X_2 equals Mileage. The result of the estimating model on pooled data for FY95 and FY96 is:

$$\text{Vehicles} = 31.8 + 0.460 (\text{Recruiters}) + 0.000013 (\text{Mileage}).$$

Figure 4.10 shows the full Minitab results for the pooled estimating model using data from FY95 and FY96. The number of recruiters and the total vehicle mileage variables were determined to be statistically significant as evidenced by the t-ratios greater than 2.0, a high F-statistic (78.9), and an adjusted R^2 of 0.719. Contracts and Size variables were dropped because of their low t-ratios and p-values. Figure 4.11 displays the Minitab results for a model that includes Contracts and Size as the independent variables. The F-statistic falls by half, and t-ratios for Contracts and Size are below 2.0.

The F-value for the pooled estimating model is 78.89. This F-value rejects the null hypothesis that the β 's in the model are jointly equal to zero. The t-tests of the individual Beta coefficients, 4.70 for the constant coefficient value, 5.79 for Recruiters, and 2.74 for Mileage, demonstrate that each variable contributes to predicting Y , the dependent

The regression equation is: $\text{Vehicles} = 31.8 + 0.460 (\text{Recruiters}) + 0.000013 (\text{Mileage})$

Predictor	Coef	Stdev	t-ratio	p
Constant	31.758	6.751	4.70	0.000
Recruiters	0.45961	0.07937	5.79	0.000
Mileage	0.00001342	0.00000489	2.74	0.008

s = 7.929 R-sq = 72.8% R-sq(adj) = 71.9%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	2	9918.2	4959.1	78.89	0.000
Error	59	3709.0	62.9		
Total	61	13627.2			

SOURCE	DF	SEQ SS
Recruiters	1	9445.2
Mileage	1	473.0

Figure 4.10. Minitab Result Using Pooled Variables From FY95 and FY96 Data File.

The regression equation is:

$\text{Vehicles} = 41.2 + 0.520(\text{Recruiters}) + 0.000012(\text{Mileage}) - 0.000027(\text{Size}) - 0.00752(\text{Contracts})$

Predictor	Coef	Stdev	t-ratio	p
Constant	41.225	8.688	4.74	0.000
Recruiters	0.5205	0.1093	4.76	0.000
Mileage	0.00001224	0.00000471	2.60	0.012
Size	-0.00002738	0.00001500	-1.83	0.073
Contracts	-0.007516	0.004134	-1.82	0.074

s = 7.569 R-sq = 76.0% R-sq(adj) = 74.4%

Analysis of Variance

SOURCE	DF	SS	MS	F	p
Regression	4	10362.0	2590.5	45.22	0.000
Error	57	3265.2	57.3		
Total	61	13627.2			

SOURCE	DF	SEQ SS
Recruiters	1	9445.2
Mileage	1	473.0
Size	1	254.4
Contracts	1	189.4

Figure 4.11. Minitab Results For Pooled FY95 and FY96 Data Adding Size and Contracts as Explanatory Variables.

variable. Likewise, the p-values, 0.000 for the constant coefficient, 0.000 for Recruiters and 0.008 for Mileage indicate that each variable contributes to predicting the Y value.

The last statistic to be discussed is the adjusted coefficient of determination, adjusted R^2 . The adjusted R^2 for this model is 71.9 percent. This means that X_1 and X_2 account for (or explains) an estimated 72 percent of the variation of Y (the predicted allowance of vehicles), the dependent variable.

F. RESULTS OF ESTIMATING A LOG-LOG MODEL

To examine a second functional form, and to estimate the elasticity of the Beta coefficients for the two variables, Recruiters and Mileage, a log-log model was estimated. Running the least squares estimation method using the logged values of both the independent and dependent variables from the pooled data resulted in the following equation:

$$\text{Log (Vehicles)} = 0.284 + 0.488 \text{ Log (Recruiters)} + 0.252 \text{ Log (Mileage)}.$$

In the log-log model the estimated coefficients provide the elasticities for each explanatory variable. The elasticity of Vehicles to Recruiters is defined as the percentage change of Vehicles divided by the percentage change of Recruiters and is given by β_1 (0.488). The elasticity of Vehicles to Mileage is defined as the percentage change of Vehicles divided by the percentage change of Mileage and is given by β_2 (0.252). This shows that if the amount of total mileage per District increased by 10 percent, then the amount of vehicles would increase by 2.5 percent. Likewise, if the amount of recruiters per District increased by 10 percent, then the amount of vehicles would increase by 4.8 percent. By estimating a

logarithmic model, it is evident that Recruiters are approximately twice as important in explaining the variation in the number of vehicles as Mileage.

G. USING REGRESSION MODELS TO PREDICT VEHICLE DEMAND

How do the results in this section translate into something CNRC can use? The model can be used to predict the number of future vehicles to be distributed at each NRD. The number of vehicles will change in direct proportion to the number of X_1 (Recruiters) and the amount of X_2 (Mileage). For example, in FY96 CNRC could have determined that NRD New York should have been allocated 117 vehicles based on having 129 enlisted recruiters assigned and 2,010,840 total miles driven for vehicles onboard. Table 4.3 displays the predicted number of vehicles using FY96's data file. The results are compared with FY97's actual number of vehicles onboard and the difference is computed between the two values. The sum of the differences (last column) shows that based on this model, CNRC should have allocated a total of 30 more vehicles than they did. For example, according to the model, Minneapolis would have received 15 more vehicles, while New England would have received 13 fewer vehicles.

One deficiency of this model is that Mileage may not a reliable indicator for predicting the number of vehicles, because at best it can only be an estimate for the upcoming fiscal year. The prediction exercise assumes that estimated β 's remain fixed over time. So, if we want to predict number of vehicles for District "X" then we "plug-in" the forecasted number of recruiters and mileage. CNRC will plan the number of recruiters for each NRD in advance, so then we only need a forecast value of mileage. The key to

the exercise is in having forecasted values of the explanatory variables. CNRC can write these equations into an EXCEL spreadsheet then input the forecasted values of X_1 and X_2 and solve for Vehicles.

Using the vehicle and mileage costs derived by CNRC Operations Analysis department for each Area (located in the Appendix), the model can also be used to give CNRC an estimate of how much funding each district will need for vehicles. Given this type of information, CNRC Comptroller can review its vehicle budget to determine how much funding will be needed for future fiscal years. The next section discusses this in more detail.

AREA	NRD #	NRD NAME	FY96RECS	FY96Mileage	1997 Predicted Vehicles	1997 Actual Vehicles	Difference
1	102	NEW ENGLAND	135	1,784,880	117	130	-13
1	103	BUFFALO	126	1,980,720	116	119	-3
1	104	NEW YORK	129	2,010,840	117	124	-7
1	119	PHILADELPHIA	155	1,819,908	127	139	-12
1	120	PITTSBURGH	134	2,187,432	122	122	0
3	310	MONTGOMERY	130	2,362,536	122	114	8
3	312	JACKSONVILLE	125	1,883,448	114	108	6
3	313	ATLANTA	158	2,467,584	137	138	-1
3	314	NASHVILLE	122	2,155,140	116	116	0
3	315	RALEIGH	135	2,198,664	122	115	7
3	316	RICHMOND	137	2,002,932	121	120	1
3	318	OHIO	137	2,113,800	122	130	-8
3	334	NEW ORLEANS	120	1,928,640	112	111	1
3	348	MIAMI	129	1,574,316	112	111	1
5	521	CHICAGO	136	2,113,632	122	118	4
5	527	KANSAS CITY	124	2,147,328	117	121	-4
5	528	MINNEAPOLIS	111	1,807,656	106	91	15
5	529	OMAHA	110	2,130,624	110	100	10
5	531	DALLAS	129	1,877,040	116	105	11
5	532	HOUSTON	128	1,989,960	117	127	-10
5	542	INDIANAPOLIS	107	1,949,976	106	117	-11
5	547	ST. LOUIS	128	2,277,000	120	121	-1
8	822	MICHIGAN	140	2,190,096	125	125	0
8	825	DENVER	99	1,513,680	97	87	10
8	830	ALBUQUERQUE	109	1,337,436	99	110	-11
8	836	LOS ANGELES	171	2,316,744	141	140	1
8	837	PORTLAND	106	1,527,624	100	95	5
8	838	SAN FRANCISCO	182	2,629,200	150	143	7
8	839	SEATTLE	119	1,624,344	108	98	10
8	840	SAN DIEGO	156	2,217,420	132	126	6
8	846	SAN ANTONIO	132	1,963,080	118	109	9
						Total=	30

Table 4.3. Predicted vs Actual Number of Vehicles for FY97.

V. SUMMARY AND RECOMMENDATIONS

A. SUMMARY

This study focused on the development of a predicting model which could be used by CNRC to aid in the distribution of vehicles across the 31 Navy Recruiting Districts and four Areas. By using the model, the allocation decision can be reviewed across all subordinate commands. This thesis first attempted to look at potential explanatory variables to explain the variation in the number of vehicles across Districts. Next, it identified and analyzed a data set based on pooled, cross-sectional time-series data for the 31 NRD's for a period of three years. The data set was analyzed to determine those variables which were significant in explaining the variation in the number of vehicles. Lastly, the thesis estimated various regression models using the ordinary least squares estimation method on pooled data for two fiscal years to obtain a model to predict vehicle demand.

The data file collected for this study was evaluated for its potential use in future vehicle decision analyses. Although several broad categories of data were collected, the amount of historical data available was limited. Complete data for all four categories were available for only two fiscal years, 1995 and 1996. Two variables, Mileage and Contracts, are missing for fiscal year 1997 which further restricted the usable sample for analysis in the pooled model. In this thesis, three different explanatory variables were found to be significant in the various regression models: Recruiters, Mileage, and Size.

As the results of all three statistical regressions demonstrate, there is a very close relationship between the number of Recruiters and the dependent variable, the number of vehicles. The second explanatory variable, Mileage, is collinear with Recruiters, but its t-ratios and p-values for the FY95 estimating model and the pooled model are significant and, hence, it was kept in the final estimating model. The third explanatory variable, Size, is statistically significant as shown in FY96's estimating model. However, as an explanatory variable it is not an appropriate indicator because a District's size is not a reflection of the actual distance recruiters travel as part of their job. For example, NRD Omaha contains 286,714 square miles as opposed to NRD New York which contains only 5,258 square miles. However, because New York is more densely populated than Omaha there are more recruiting stations and, consequently, more recruiting vehicles. The distance between these recruiting stations to the centroid of a population sub-unit (such as ZIP codes) may be a more realistic variable to analyze than a District's size.

B. RECOMMENDATIONS

CNRC's main concern is to develop a predicting model to ensure a fair method of distributing vehicles to their subordinate commands to efficiently and effectively meet the recruiting mission. This thesis looked at developing a preliminary model to assist the Comptroller in allocating funds for vehicles and in distributing vehicles to the Districts. Interviews with CNRC Comptroller, LCDR Blair Stephenson and Operations Analysis Code 221, LCDR Paul Soutter, indicated that recruiting Districts and Areas have traditionally used historical numbers to determine their vehicle budget and requested

number of vehicles. If this is the case, then the data collected, such as number of vehicles onboard, is not a reliable measurement against the current Navy's model for vehicle allocation. In other words, the number of vehicles allocated in the past were not completely based on the number of billets authorized (BA) as described in Table 2.1, but rather on some other (possibly random) methodology. The Navy's current model used to allocate the number of vehicles to an Area and District was not utilized as had previously been thought. Likewise, it can be concluded that vehicle budgets in the past were allocated based on the previous year's budget amount plus an additional amount factored in for inflation and accidents.

Another weakness of the predicting model in this thesis is that it does not take into account the additional administrative personnel who are entitled to vehicles, such as the Commanding Officer, Enlisted and Officer Production Officers, and District Training Officers. In the pooled model, the value of the constant term in the model of 31.8 signifies that each NRD would at least receive 32 vehicles regardless of the number of enlisted recruiters and the total mileage of vehicles. This constant coefficient value indicates that there is a significant amount of fixed assets determined by variables other than the ones used in the estimating models.

Perhaps the most useful benefit this thesis provides is the elimination of certain independent variables thought to have an impact on the number of vehicles allocated. For example, Contracts and Mileage are not reliable determinants to explain the number of vehicles distributed, because these variables at best can only be estimates when inputted

into the predicting model. The conclusion that there is a strong relationship between Recruiters and the predicted number of vehicles validates the Navy's current methodology of basing the number of vehicles on the number of billets filled.

The quantifiable variables used to determine a predicting model for the *allocation of vehicles* have been determined in this thesis. The vehicle cost data collected by CNRC is useful in determining the *allocation of a vehicle budget*. For example, if NRD New York is allocated 117 vehicles of which 110 are sedans with a total mileage of 1,110,000 miles and seven are cargo vans with a total mileage of 1,000,000 miles, then a total cost of vehicles for FY96 can be calculated as follows:

$$\begin{aligned}\$ \text{ Total Vehicle Cost} &= \$50,000 + \$136.10 (110) + \$152.76 (7) \\ &\quad + \$0.11 (1,110,000) + \$0.19 (1,000,000)\end{aligned}$$

$$\$ \text{ Total Vehicle Cost} = \$378,140,$$

where \$50,000 is an estimated amount for vehicle accidents and repairs [Ref. Appendix C], \$136.10 is a monthly lease cost for a sedan in Area One, \$152.76 is a monthly lease cost for a cargo van in Area One, \$0.11 is the cost per mile for a sedan, and \$0.19 is the cost per mile for a cargo van [Ref. Appendix D].

There are several recommendations for future research in this area:

1. Use the pooled model with additional data sets from previous years to re-estimate and validate the predicting model.

2. Develop the predicting model to include other variables, such as total number of officer personnel and total distance between the centroid of a zip code area and each recruiting station vice District size.

In summary, this thesis has investigated several of the quantitative variables that affect the vehicle allocation decision process in the Navy. It has also shown that quantitative analysis tools can be useful in determining the allocation of other resources. Its conclusions, based on statistical analysis, data collection and personal interviews are applicable mostly to the Navy, but can be applied to the vehicle transportation management of other services.

APPENDIX A.

LIST OF NAVY RECRUITING AREAS AND DISTRICTS

AREA One, Scotia, NY

Districts

**Buffalo
Columbus
Germany
London
New York
New England
Michigan
Philadelphia
Pittsburgh**

AREA Three, Macon, GA

Districts

**Atlanta
Jacksonville
Miami
Montgomery
Nashville
New Orleans
Raleigh
Richmond**

AREA Five, Great Lakes, IL

Districts

**Chicago
Dallas
Houston
Kansas City
Minneapolis
Omaha
St. Louis**

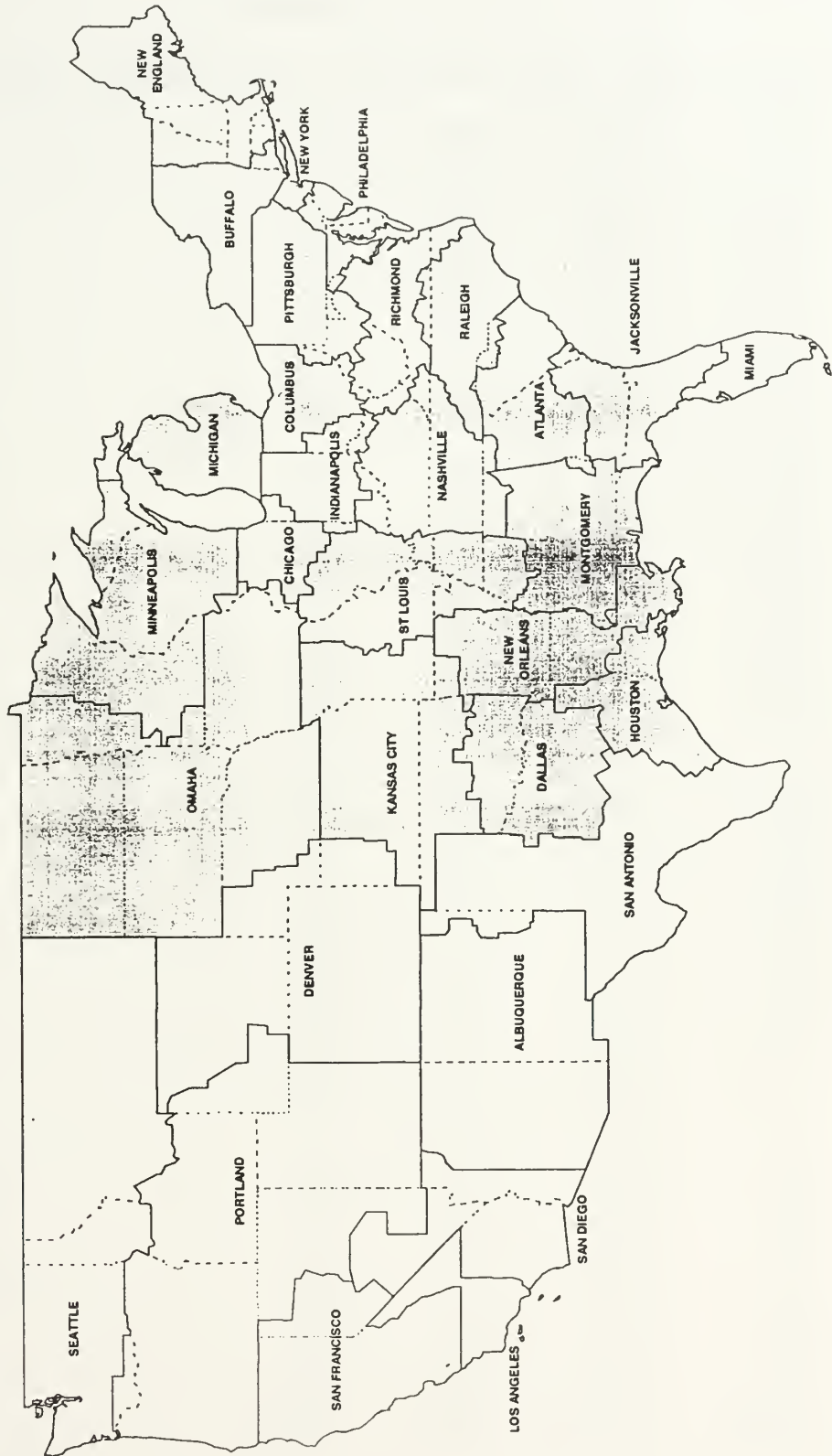
AREA Eight, Oakland, CA

Districts

**Albuquerque
Denver
Los Angeles
Portland
San Antonio
San Diego
San Francisco
Seattle**

APPENDIX B

MAP OF NAVY RECRUITING DISTRICTS



APPENDIX C

FY 94 - 97 ACCIDENT COSTS (IN \$) BY RECRUITING AREA AND DISTRICT

	FY94	FY 95	FY 96	FY 97
AREA 1				
NRD NEW ENGLAND	\$23625	\$24600	\$12,650	\$1000
NRD BUFFALO	50,946	34,512	22,334	52,649
NRD NEW YORK	74,295	78,210	50,000	16,000
NRD COLUMBUS	N/A	23,133	28,885	24,301
NRD PHILADELPHIA	62,999	52,384	16,305	14,486
NRD PITTSBURGH	23,182	19,912	3,522	5,565
NRD MICHIGAN	N/A	36,715	15,821	13,400
TOTAL	211,422	244,865	136,867	126,401
AREA 3				
NRD MONTGOMERY	12,712	10,384	19,699	8,000
NRD JACKSONVILLE	20,643	4,874	6,722	6,000
NRD ATLANTA	9,953	18,186	17,784	12,034
NRD CUMBERLAND VALLEY	17,472	10,471	23,433	18,000
NRD RALEIGH	17,811	10,027	39,406	16,359
NRD RICHMOND	15,178	17,679	18,185	4,424
NRD NEW ORLEANS	18,692	25,484	32,613	20,498
NRD MIAMI	16,204	32,679	22,500	10,200
TOTAL	128,665	129,784	180,343	95,515
AREA 5				
NRD COLUMBUS	22,385	N/A	N/A	N/A
NRD CHICAGO	33,441	24,066	20,500	17,000
NRD KANSAS CITY	15,851	20,120	19,913	6,981
NRD MICHIGAN	41,616	N/A	N/A	N/A
NRD MINNEAPOLIS	21,240	16,799	30,800	17,750
NRD OMAHA	11,269	19,871	12,877	32,960
NRD DALLAS	11,211	14,181	21,067	14,426
NRD HOUSTON	16,135	15,091	13,200	6,928
NRD INDIANAPOLIS	32,910	17,664	27,531	17,468
NRD ST. LOUIS	23,218	9,900	33,399	24,000
TOTAL	229,276	137,691	179,286	137,513
AREA 8				
NRD DENVER	8,753	11,775	17,662	17,922
NRD ALBUQUERQUE	4,796	4,306	4,563	30,481
NRD LOS ANGELES	21,139	46,068	33,540	20,000
NRD PORTLAND	5,333	10,444	14,885	27,162
NRD SAN FRANCISCO	33,740	66,000	46,134	72,071
NRD SEATTLE	8,506	19,894	19,863	10,000
NRD SAN DIEGO	18,149	36,084	21,139	34,235
NRD SAN ANTONIO	37,417	34,886	21,841	11,300
TOTAL	137,833	229,457	179,627	223,171
CNRC TOTAL	\$730,821	\$66,397	\$688,773	\$583,599
Notes: N/A = Not Available				

APPENDIX D

VEHICLE COSTS BY RECRUITING AREA

CLASS	VEHICLE TYPE	% OF TOTAL FLEET	TOT AREA1		TOT AREA3		TOT AREA5		TOT AREA8		TYPE TOTALS		BASE COST AREA1		BASE COST AREA3		BASE COST AREA5		BASE COST AREA8		MILE COST AREA1		MILE COST AREA3		MILE COST AREA5		MILE COST AREA8		TOT BASE COSTS AREA1		% OF TOT		TOT BASE COSTS AREA3		% OF TOT		TOT BASE COSTS AREA5		% OF TOT		TOT BASE COSTS AREA8		% OF TOT		TOT BASE COSTS ALL		% OF TOT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			TOT AREA1	TOT AREA3	TOT AREA5	TOT AREA8	BASE COST AREA1	BASE COST AREA3	BASE COST AREA5	BASE COST AREA8	MILE COST AREA1	MILE COST AREA3	MILE COST AREA5	MILE COST AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS AREA1	TOT BASE COSTS AREA3	TOT BASE COSTS AREA5	TOT BASE COSTS AREA8	TOT BASE COSTS ALL	% OF TOT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
G-10	SEDAN, PASS	81.6	763	809	760	637	2969	136.1	136.1	136.1	129	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0

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